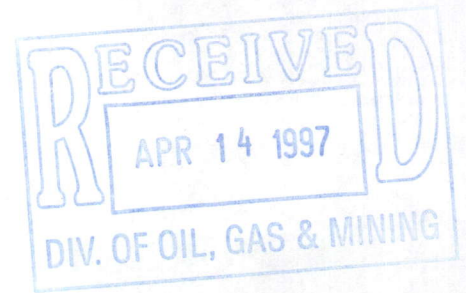




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**CONTINENTAL LIME
REVEGETATION REPORT**

April 9, 1997

Continental Lime Revegetation Report

1.0 Introduction

The Cricket Mountain Plant, owned and operated by Continental Lime Inc., is an active limestone mine located south of Delta, Utah. Continental Lime Inc. is in the process of using a variety of treatments to revegetate limestone benches resulting from mining. Experimental test plot pairs are also present as well as topsoil stockpiles which are revegetating naturally. The objectives of the work reported here were to assess the current condition of the experimental test plots and benches and to evaluate the potential of naturally occurring species to revegetate future bench sites. Mr. Victor L. Kastner, Continental Lime's Quarry Supervisor, accompanied Dames & Moore personnel in the field to assure that all sites were accurately located.

2.0 Methods

Test plot pairs, bench revegetation sites, and topsoil stockpiles were surveyed on March 28, 1997. For the test plot pairs, data was collected on number and condition of shrubs, percent ground cover, and species present. High vigor was defined as a healthy shrub with many stems, moderate vigor as a shrub with five to ten stems, and low vigor as a shrub with few stems, and very low vigor as a shrub with one stem. For the bench revegetation sites, plant species data was collected and plant density and mulch cover were observed. For the topsoil stockpiles, a species list was compiled. Taxonomy follows Welsh et al. A Utah Flora, 1993. Site photographs are provided in Appendix A.

3.0 Results

3.1 Test Plot Pairs

Two sets of fenced 10-foot square test plots pairs were established in 1989. All plots were covered with 4 inches of minus 3/4-inch limestone reject waste, fertilized with 11-50-0 (N,P,K) fertilizer, seeded with a mix of mostly drought tolerant species, and covered with straw mulch. The seed mix was rubber rabbitbrush (*Chrysothamnus nauseosus*), winterfat (*Ceratoides lanata*), four-wing saltbush (*Atriplex canescens*), western wheatgrass (*Agropyron smithii*), galleta grass (*Hilaria jamesii*), thickspike wheatgrass (*Elymus lanceolatus*), streambank wheatgrass (*Agropyron riparium*), Indian ricegrass (*Stipa hymenoides*), Russian wildrye (*Elymus junceus*), and crested wheatgrass (*Agropyron cristatum*). One plot in each set also received 4 inches of mushroom mulch.

3.1.1 North and South Test Plots

North Test Plot

The North test plot had approximately 90 percent cover of shrubs, grasses, and litter. Litter included rubber rabbitbrush leaves and seedheads. Seventy-five percent of the plot cover was

vigorous rubber rabbitbrush (See Photo 1). Five percent of the plot cover was provided by two small clumps of crested wheatgrass and scattered grasses coming up through the litter. Inside the plot fence, eight large (> 1 m), one small (< 0.5 m), and six sapling rubber rabbitbrush were present. In addition, five large and five small rubber rabbitbrush were present immediately adjacent to the plot.

South Test Plot

The South test plot had approximately eighty percent cover of shrubs, grasses, and litter. Ten percent of the plot cover was of moderately vigorous rubber rabbitbrush and shadscale (*Atriplex confertifolia*) (See Photo 2). About fifty percent of the plot cover was grasses and about twenty percent of the plot cover was litter. Inside the plot fence, one large (> 1 m) rubber rabbitbrush, three small (< 0.5 m) rubber rabbitbrush, and two medium (< 0.5 to 1.0 m) shadscale were present. In addition, five large, one medium, two small, and seven very small (< 0.1 m) rubber rabbitbrush were present immediately adjacent to the plot.

3.1.2 East and West Test Plots

East Test Plot

The East test plot had approximately ninety percent cover by shrubs, grasses, and litter. Thirty percent of the plot cover was four-wing saltbush with low or very low vigor (Photo 3). About sixty percent of the plot cover was grasses and litter. Two clumps of seeded crested wheatgrass were present, but most grass cover was of cheatgrass (*Bromus tectorum*). Four medium (< 0.5 to 1.0 m), low vigor four-wing saltbush and five very small (< 0.1 m), very low vigor four-wing saltbush were present.

West Test Plot

The West test plot had approximately twenty percent cover comprised of shrubs, grasses and straw mulch. Ten percent of the plot cover was of medium vigor rubber rabbitbrush (Photo 4). About one percent of the plot cover was provided by one clump of crested wheatgrass and one clump of dormant grass and about ten percent of the plot cover was straw mulch. Four medium-small (about 0.5 m) and six small (< 0.5 m) rubber rabbitbrush were present as well as four very small (< 0.1 m) unidentified dead shrubs.

3.2 Revegetated Benches

Benches in the Poison Mountain quarry were fertilized, seeded with drought-tolerant species, and mulched. The seed mix was crested wheatgrass, pubescent wheatgrass (*Elymus hispidus*), Russian wildrye, prostrate kochia (*Kochia prostrata*), yellow sweetclover (*Melilotus officinalis*), shadscale, and four-wing saltbush. Fertilizer, mulch treatment, and season of seeding varied.

3.2.1 Benches Seeded in April 1996

Benches seeded in April 1996 received 40 pounds per acre of 16-20-0 fertilizer, 12 pounds per acre of seed mix, and varying mulch treatments.

Bench 5960 W

Bench 5960 W had a growth media of limestone fines and received 1000 pounds per acre of straw mulch. Bulldozer tracks and small patches of crimped-in straw were visible (Photo 5). Vegetation consisted of one very small sprig of a goosefoot species from last year's growing season and one clump of grass (probably Russian wildrye), both in straw mulch at the north end of the bench.

Bench 5940 W

Bench 5940 W had a growth media of limestone fines and received 1000 pounds per acre of hay mulch. Bulldozer tracks and small patches of crimped-in straw were visible (Photo 6). Vegetation was composed of two very small forbs, probably four-wing saltbush.

Bench 5940 NW

Bench 5940 NW has a growth media of topsoil and received 2000 pounds per acre of hay mulch. Only small scattered clumps of straw remain. Vegetation was widely scattered pubescent wheatgrass, crested wheatgrass, alfalfa, a goosefoot (probably kochia), and four-wing saltbush seedlings.

3.2.2 Benches Seeded in December 1996

Benches seeded in December 1996 received 50 pounds per acre of 16-16-8 fertilizer, 20 pounds per acre of seed mix, and varying mulch treatments. Growth media was limestone fines.

Bench 5920 W

Bench 5920 W received 3000 pounds per acre of straw mulch. Cobbles and boulders are present and about fifty percent of the surface is covered with straw mulch (Photo 7). A few clumps of Russian wildrye were present in areas of thick straw.

Bench 5900 W

Bench 5900 W received 2300 pounds per acre of straw mulch. Bulldozer tracks and small patches of crimped-in straw were visible (Photo 8). No vegetation was present.

Bench 5900 NW

Bench 5900 NW received 1000 pounds per acre of hay mulch. A few grasses (probably crested wheatgrass and Russian wildrye) and alfalfa were present in areas of thick hay at the south and north ends of the bench.

Bench 5900 E

Bench 5900 E received 1500 pounds per acre of straw mulch. Bulldozer tracks and patches of crimped-in straw were visible (Photo 9). A few grasses (probably Russian wildrye) were present in the thick straw at the north end.

Bench 5940 E

Bench 5940 E received 2500 pounds per acre of straw mulch. A thick straw cover was present except at south end (Photo 10). A few scattered grasses (probably Russian wildrye) were present in the straw.

3.3 Topsoil Stockpiles

Upper PM

Upper PM is composed of piles of fines with cobbles, boulders, and juniper debris. Except for a very few widely scattered goosefoot (*Chenopodiaceae*) at the bottom of the west-facing slope, vegetation cover was 0 percent (Photo 11).

Lower PM

Lower PM has about eighty percent vegetation and litter cover. Shadscale is the dominant shrub. Clumps of cheatgrass and wheatgrass (*Agropyron* sp.) are present as well as a tall mustard species (probably tumble mustard [*Sisymbrium altissium*]), Russian thistle (*Salsola* sp.), and a goosefoot species (probably *Kochia*) (Photo 12).

PM Fines Topsoil

PM Fines Topsoil has about ninety percent vegetation cover. The dominant species is a tall mustard (probably tumble mustard) with widely scattered shadscale, winterfat and some grasses (Photo 13).

PM Crusher Topsoil

PM Crusher Topsoil has with about 50 percent vegetation cover. The dominant species is a goosefoot forb with some grasses, Russian thistle, cheatgrass, wheatgrass, mustard species (Photo 14).

3.4 Soil Analysis

Soils of the catch benches are alkaline, ranging in pH from 8.0 to 8.8, but within the limits conducive to plant growth (Table 1). Electrical conductivity, cation exchange capacity, phosphate, and potassium levels are high on the topsoil stockpiles. Electrical conductivity values greater than 8 to 16 micromhos/cm are limiting to many agronomic and reclamation species (Szabolcs 1989), but not to many naturally-occurring species of the area (e.g., saltbushes). Reclamation seed mix recommendations should be based on species' tolerances to high soil salinity. Total nitrogen levels are adequate, but nitrate/nitrite levels are low. Results for percent organic matter are not included since a laboratory test for total organic carbon is necessary for limestone derived soils.

Table 1. Soil Analysis

	pH	Electrical Conductivity (micromhos/cm)	Sodium Absorption Ratio (mg/Kg)	Cation Exchange Capacity (meq/100 g)	Total Nitrogen (ppm)	Nitrate Nitrite (ppm)	Phosphate (ppm)	Potassium (ppm)
Limiting Threshold Value	<5 and >9	> 8 to 16	> 3	NA	NA	>20		<40
Catch Benches	8.8	12	0.06	9.6	150	2.0	39	100
Upper PM	8.7	18	0.4	320	360	0.30	440	4,100
Lower PM	8.6	10	0.3	290	410	0.51	410	4,200
PM Fines Topsoil	8.2	13	0.3	320	600	0.20	800	5,900
PM Crusher Topsoil	8.0	16	0.3	350	250	0.43	500	5,200

The North and South test plots are isolated squares of vegetation on a sparsely vegetated bench. Although the upper layer of soil in the two plots appeared similar, it is probable that the more densely vegetated North plot received the mushroom compost treatment. From the March 1997 vegetation study it is apparent that on this substrate seeding alone resulted in shrub establishment and it is likely that seeding in conjunction with application of organic matter resulted in establishment of vigorous shrubs with successful reproduction.

The East and West test plots are isolated squares of vegetation in an unvegetated flat depression. Although the upper layer of soil in the two plots appeared similar, it is probable that the more densely vegetated East plot received the mushroom compost treatment. From the March 1997 vegetation study it is apparent that on this substrate seeding alone resulted in some shrub establishment and it is likely that seeding in conjunction with application of organic matter results in establishment of a higher shrub and grass cover.

During this site survey vegetation was very sparse or non-existent on the eight bench revegetation sites. Bench 5940 NW with the topsoil growth media had both more individual plants and more species diversity than benches with limestone fines growth media. It is likely that the lack of organic material and a very well-drained, very hot substrate contributed to the absence of vegetation cover. Nearly all of the widely scattered seeded grasses are present in the straw or hay mulch. Tracking these sites through several growing seasons will be necessary to determine if variations in fertilizer type, mulch type, and mulch amount contribute to successful revegetation.

The topsoil stockpiles, except for Upper PM, were developing vegetation. On Upper PM it is likely that the lack of organic material and seeds combined with rapidly draining substrate have precluded vegetation cover. The shadscale and wheatgrass which invaded Lower PM are highly desirable revegetation species. Vegetation cover is approaching that of nearby undisturbed areas and it is likely that the lumpy microtopography caused by dumping of material has benefitted plant growth by creating moister, less windy microsites for seedling establishment. The adjacent native vegetation is one-seed juniper (*Juniperus osteosperma*) and sagebrush (*Artemisia* sp.) with Mormon tea (*Ephedra viridis*), phlox (*Phlox*) species and grasses. In contrast, PM Fines Topsoil, although more densely vegetated, has developed a more weedy vegetation cover. The adjacent undisturbed wide valley is vegetated with grasses (including cheatgrass), sagebrush, shadscale, and Mormon tea. Ungulate (possibly deer) tracks and droppings were present at the time of the survey. PM Crusher Topsoil has a lower vegetation cover than Piles B and C which may be due to more recent construction.

Additional soil sampling and analyses should be conducted for test plot pairs, revegetated benches, and topsoil stockpiles to facilitate using species that are most tolerant of the soils, and to determine what soil amendments could be used to ameliorate certain soil conditions.

Further revegetation efforts could be enhanced by the use of topsoil or mulched compost spread to create a lumpy microtopography similar to Lower PM and seeding with rubber rabbitbrush, shadscale, sagebrush, Mormon tea, and one-seed juniper.

5.0 Literature Cited

Szabolcs, I. 1989. Salt-affected Soils. Boca Raton: CRC Press, Inc.

Welsh, S.L., Atwood, N.D., Goodrich, S. and L.C. Higgins. 1993. A Utah Flora. Provo: Brigham Young University.

Appendix A

Site Photographs



Photo 1. North Test Plot



Photo 2. South Test Plot



Photo 3. East Test Plot



Photo 4. West Test Plot



Photo 5. Bench 5960 W



Photo 6. Bench 5940 W



Photo 7. Bench 5920 W



Photo 8. Bench 5900 W



Photo 9. Bench 5900 E



Photo 10. Bench 5940 E



Photo 11. Topsoil Stockpile A



Photo 12. Topsoil Stockpile B



Photo 13. Topsoil Stockpile C



Photo 14. Topsoil Stockpile D